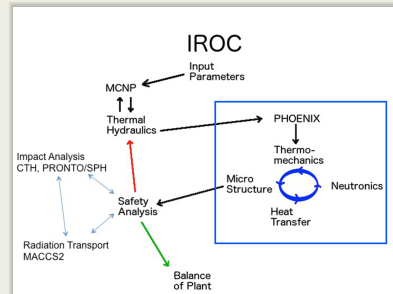# Integrated Multi-Physics and Advanced Diagnostics for NTR Development, Phase I

Completed Technology Project (2014 - 2014)

Project Introduction

Historically, designing a nuclear thermal rocket engine and determining fuel performance has been a refractory and anfractuous process. Typically, fuel forms would be developed and tested in separate tests of mechanical, radiation and thermal testing, and, in the NERVA program, the fuel elements were assembled in a rocket engine and tested. The fuel did not perform to expectations, and the engine needed to be disassembled, the fuel examined and fixed needed to be determined; then the process would repeat itself. In the Space Nuclear Thermal Propulsion Program, individual fuel elements were tested, but they could not be tested to full power density due to test reactor limitations. Nevertheless, this was a far less expensive approach that full engine testing to determine whether the fuel elements in particular would withstand the rigors of the NRE (Nuclear Rocket Engine) mission. This proposal outline how LPS and its team members plan to integrate the latest in multi-physics model to simulate a fuel element based on a particular NRE design built up from designer parameters. The multi-physics modules can determine fuel integrity and fission product retention as a function of temperature and operating times, determine micro-structure evolution including cracking and grain growth. The fuel element parameters are derived from high level NRE requirements via the integration of the IROC (Integrated Rocket Optimization Code), linked with PHOENIX, a program linking multi-physics modules through MOOSE (Multi-physics Object-Oriented Simulation Environment) Ultimately, detailed safety related information including results of impact analyses through extensive hydro-codes such as PRONTO/SPH and radiation transport codes such as MACCS2. This enables safety to be integrated in from the very beginning of the design process resulting in a much more optimized safety based nuclear rocket engine.

Integrated Multi-Physics and Advanced Diagnostics for NTR Development Project Image
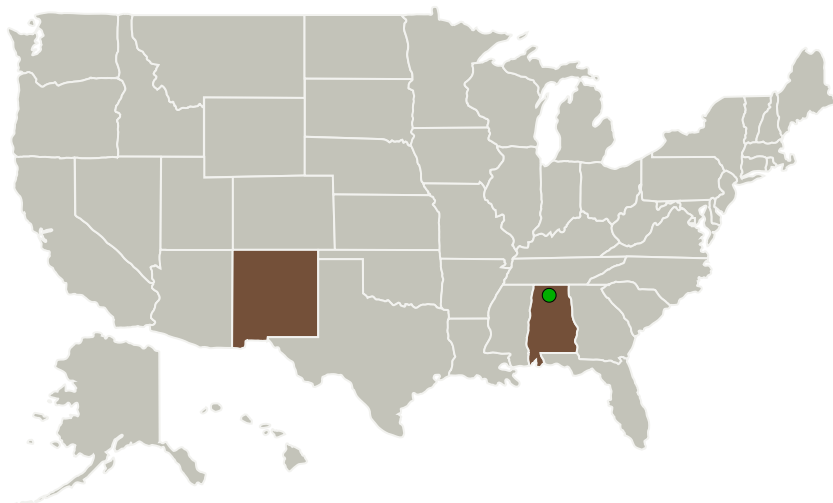
Table of Contents

Primary U.S. Work Locations and Key Partners

Organizations Performing Work	Role	Type	Location
Little Prairie Services	Lead Organization	Industry Veteran-Owned Small Business (VOSB)	Edgewood, New Mexico
● Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama

Primary U.S. Work Locations	
Alabama	New Mexico

Project Transitions

▶ **June 2014:** Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Little Prairie Services

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:
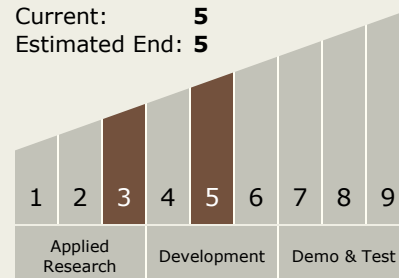
Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Roger X Lenard

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

✅ **December 2014:** Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/137693)*
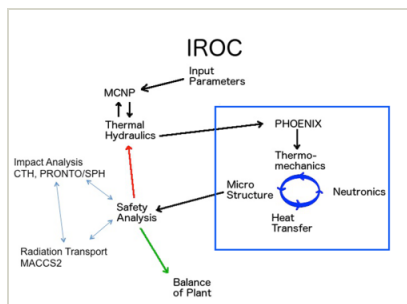
Images

Project Image
Integrated Multi-Physics and Advanced Diagnostics for NTR Development Project Image
(https://techport.nasa.gov/image/132934)

Technology Areas

Primary:

- TX01 Propulsion Systems
  └ TX01.4 Advanced Propulsion
     └ TX01.4.3 Nuclear Thermal Propulsion

Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System